5.4.3 Earthquake

This section provides a profile and vulnerability assessment for the earthquake hazard.

Hazard Profile

This section provides profile information including description, extent, location, previous occurrences and losses and the probability of future occurrences.

Description

An earthquake is the sudden movement of the Earth's surface caused by the release of stress accumulated within or along the edge of the Earth's tectonic plates, a volcanic eruption, or by a manmade explosion (Federal Emergency Management Agency [FEMA], 2013; Shedlock and Pakiser, 1997). Most earthquakes occur at the boundaries where the Earth's tectonic plates meet (faults); however, less than 10 percent of earthquakes occur within plate interiors. New York State is in an area where plate interior-related earthquakes occur. As plates continue to move and plate boundaries change over geologic time, weakened boundary regions become part of the interiors of the plates. These zones of weakness within the continents can cause earthquakes in response to stresses that originate at the edges of the plate or in the deeper crust (Shedlock and Pakiser, 1997).

The location of an earthquake is commonly described by its focal depth and the geographic position of its epicenter. The focal depth of an earthquake is the depth from the Earth's surface to the region where an earthquake's energy originates (the focus or hypocenter). The epicenter of an earthquake is the point on the Earth's surface directly above the hypocenter (Shedlock and Pakiser, 1997). Earthquakes usually occur without warning and their effects can impact areas of great distance from the epicenter (FEMA, 2001).

According to the U.S. Geological Society (USGS) Earthquake Hazards Program, an earthquake hazard is anything associated with an earthquake that may affect resident's normal activities. This includes surface faulting, ground shaking, landslides, liquefaction, tectonic deformation, tsunamis, and seiches. A description of each of these is provided below.

- *Surface faulting*: Displacement that reaches the earth's surface during slip along a fault. Commonly occurs with shallow earthquakes, those with an epicenter less than 20 kilometers.
- *Ground motion (shaking):* The movement of the earth's surface from earthquakes or explosions. Ground motion or shaking is produced by waves that are generated by sudden slip on a fault or sudden pressure at the explosive source and travel through the earth and along its surface.
- *Landslide*: A movement of surface material down a slope.
- *Liquefaction*: A process by which water-saturated sediment temporarily loses strength and acts as a fluid, like when you wiggle your toes in the wet sand near the water at the beach. This effect can be caused by earthquake shaking.
- *Tectonic Deformation*: A change in the original shape of a material due to stress and strain.
- *Tsunami*: A sea wave of local or distant origin that results from large-scale seafloor displacements associated with large earthquakes, major submarine slides, or exploding volcanic islands.
- *Seiche*: The sloshing of a closed body of water from earthquake shaking (USGS, 2012).

Extent

Seismic waves are the vibrations from earthquakes that travel through the Earth and are recorded on instruments called seismographs. The magnitude or extent of an earthquake is a measured value of the earthquake size, or amplitude of the seismic waves, using a seismograph. The Richter magnitude scale (Richter Scale) was developed in 1932 as a mathematical device to compare the sizes of earthquakes (USGS, 1989). The Richter Scale is the most widely-known scale that measures the magnitude of earthquakes (Shedlock and Pakiser, 1997; USGS, 1989). It has no upper limit and is not used to express damage. An earthquake in a densely populated area, which results in many deaths and considerable damage, may have the same magnitude and shock in a remote area that did not cause any damage (USGS, 1989). Table 5.4.3-1 presents the Richter Scale magnitudes and corresponding earthquake effects.

Table 5.4.3-1. Richter Scale

Richter Magnitude	Earthquake Effects
2.5 or less	Usually not felt, but can be recorded by seismograph
2.5 to 5.4	Often felt, but only causes minor damage
5.5 to 6.0	Slight damage to buildings and other structures
6.1 to 6.9	May cause a lot of damage in very populated areas
7.0 to 7.9	Major earthquake; serious damage
8.0 or greater	Great earthquake; can totally destroy communities near the epicenter

Source: USGS, 1989

The intensity of an earthquake is based on the observed effects of ground shaking on people, buildings, and natural features, and varies with location. Intensity is expressed by the Modified Mercalli Scale; a subjective measure that describes how strong a shock was felt at a particular location (Shedlock and Pakiser, 1997). The Modified Mercalli Scale expresses the intensity of an earthquake's effects in a given locality in values ranging from I to XII. Table 5.4.3-2 summarizes earthquake intensity as expressed by the Modified Mercalli Scale. Table 5.4.3-3 displays the Modified Mercalli Scale and peak ground acceleration equivalent.

Table 5.4.3-2. Modified Mercalli Intensity Scale

Mercalli Intensity	Description
I	Felt by very few people; barely noticeable.
II	Felt by few people, especially on upper floors.
III	Noticeable indoors, especially on upper floors, but may not be recognized as an earthquake.
IV	Felt by many indoors, few outdoors. May feel like passing truck.
V	Felt by almost everyone, some people awakened. Small objects moves, trees and poles may shake.
VI	Felt by everyone; people have trouble standing. Heavy furniture can move, plaster can fall off walls. Chimneys may be slightly damaged.
VII	People have difficulty standing. Drivers feel their cars shaking. Some furniture breaks. Loose bricks fall from buildings. Damage is slight to moderate in well-built buildings; considerable in poorly built buildings.
VIII	Well-built buildings suffer slight damage. Poorly built structures suffer severe damage. Some walls collapse.
IX	Considerable damage to specially built structures; buildings shift off their foundations. The ground cracks. Landslides may occur.
X	Most buildings and their foundations are destroyed. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, lakes. The ground cracks in large areas.

Mercalli Intensity	Description
XI	Most buildings collapse. Some bridges are destroyed. Large cracks appear in the ground. Underground pipelines are destroyed.
XII	Almost everything is destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move.

Source(s): Michigan Tech University, 2007; Louie, J. N. Nevada Seismological Laboratory, 1996

Table 5.4.3-3. Modified Mercalli Intensity (MMI) and PGA Equivalents

MMI	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
I	< .17	Not Felt	None
II	.17 – 1.4	Weak	None
III	.17 – 1.4	Weak	None
IV	1.4 – 3.9	Light	None
V	3.9 – 9.2	Moderate	Very Light
VI	9.2 – 18	Strong	Light
VII	18 – 34	Very Strong	Moderate
VIII	34 – 65	Severe	Moderate to Heavy

Source: NYS DHSES, 2011

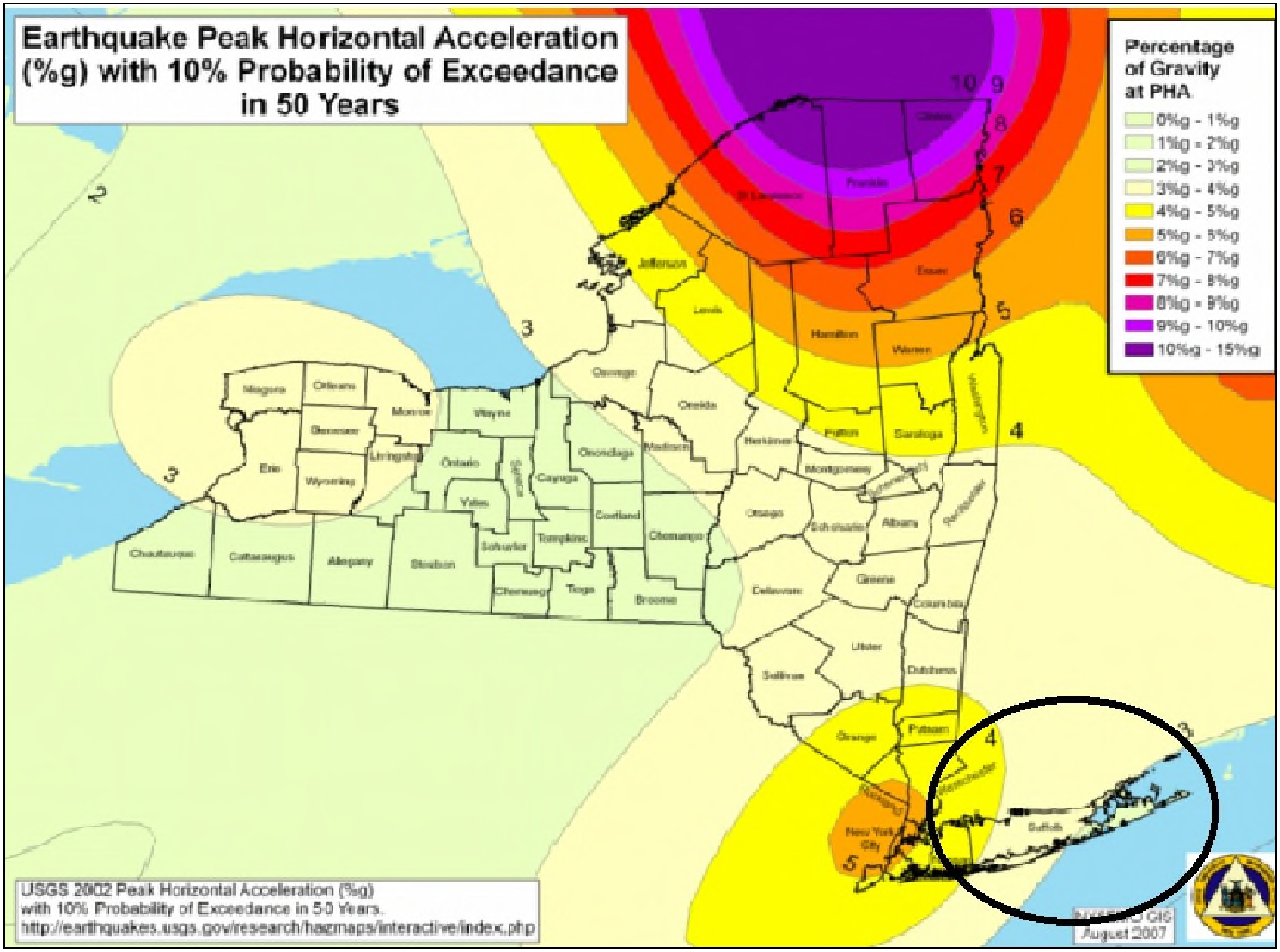
Seismic hazards are often expressed in terms of Peak Ground Acceleration (PGA) and Spectral Acceleration (SA). USGS defines PGA and SA as the following: 'PGA is what is experienced by a particle on the ground. Spectral Acceleration (SA) is approximately what is experienced by a building, as modeled by a particle mass on a massless vertical rod having the same natural period of vibration as the building' (USGS, 2012). Both PGA and SA can be measured in *g* (the acceleration due to gravity) or expressed as a percent acceleration force of gravity (%g). PGA and SA hazard maps provide insight into location specific vulnerabilities (NYS DHSES, 2011).

More specifically, PGA is a common earthquake measurement that shows three things: the geographic area affected, the probability of an earthquake of each given level of severity, and the strength of ground movement (severity) expressed in terms of percent of acceleration force of gravity (%g). In other words, PGA expresses the severity of an earthquake and is a measure of how hard the earth shakes (or accelerates) in a given geographic area (NYS DHSES, 2011).

National maps of earthquake shaking hazards have been produced since 1948. They provide information essential to creating and updating the seismic design requirements for building codes, insurance rate structures, earthquake loss studies, retrofit priorities and land use planning used in the U.S. Scientists frequently revise these maps to reflect new information and knowledge. Buildings, bridges, highways and utilities built to meet modern seismic design requirements are typically able to withstand earthquakes better, with less damages and disruption. After thorough review of the studies, professional organizations of engineers update the seismic-risk maps and seismic design requirements contained in building codes (Brown et al., 2001).

The USGS updated the National Seismic Hazard Maps in 2008, which superceded the 2002 maps. New seismic, geologic, and geodetic information on earthquake rates and associated ground shaking were incorporated into these revised maps. The 2008 map represents the best available data as determined by the USGS (NYS DHSES, 2011).

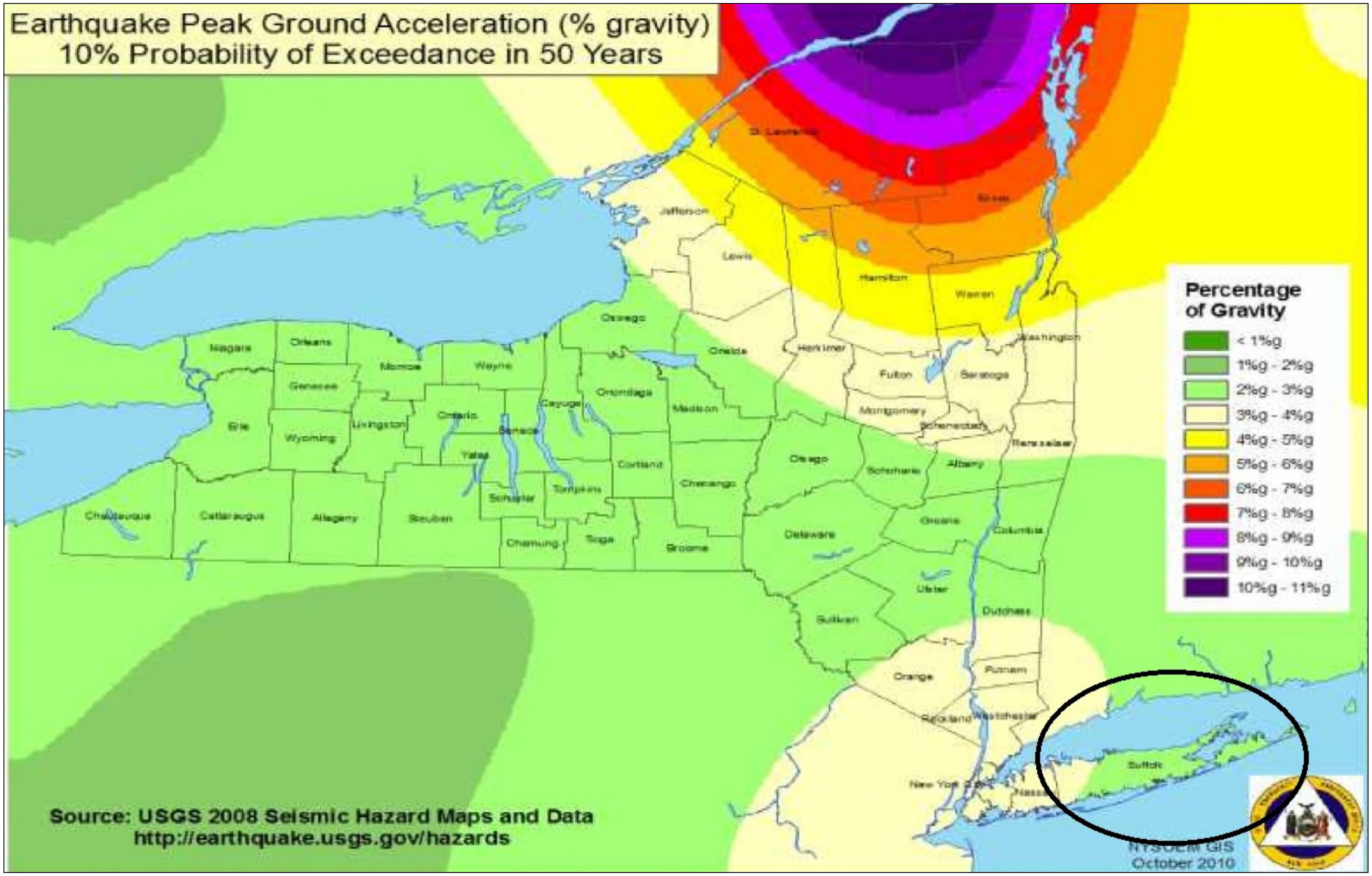
Figure 5.4.3-1. Peak Acceleration (%g) with 10% Probability of Exceedance in 50 Years (2002)



Source: NYS DHSES, 2011

Note: The black circle indicates the approximate location of Suffolk County. The figure indicates that the County has a PGA between 2%g and 5%g.

Figure 5.4.3-2. Peak Acceleration (%g) with 10% Probability of Exceedance in 50 Years (2008)



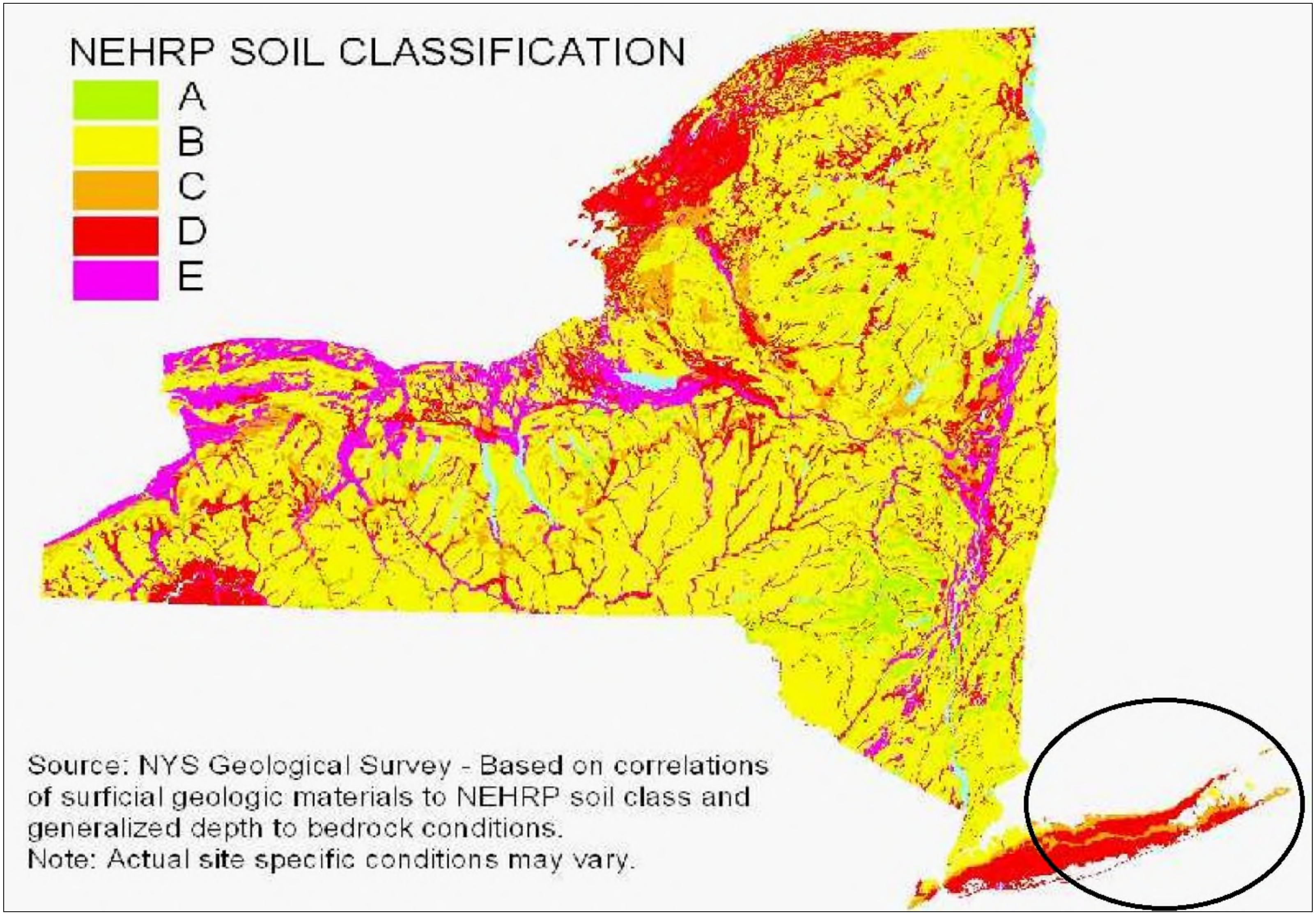
Source: *NYS DHSES*, 2013

Note: The black oval indicates the approximate location of Suffolk County. The figure indicates that the County has a PGA between 2%g and 4%g.

The 2002 Seismic Hazard Map shows that Suffolk County has a PGA between 3 and 5% (Figure 5.4.3-1). The 2008 Seismic Hazard Map shows that Suffolk County has a PGA between 2 and 4% (Figure 5.4.3-2). These maps are based on peak ground acceleration (%g) with 10% probability of exceedance in 50 years.

The New York State Geological Survey conducted seismic shear-wave tests of the State's surficial geology (glacial deposits). Based on these test results, the surficial geologic materials of New York State were categorized according to the National Earthquake Hazard Reduction Program's (NEHRP) Soil Site Classifications (Figure 5.4.3-). The NEHRP developed five soil classifications that impact the severity of an earthquake. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses. Figure 5.4.3-4 illustrates the NEHRP soil classifications in Suffolk County, as provided by NYSEMO (O'Brien, 2008). Table 5.4.3-4 summarizes the NEHRP soil classifications shown on Figure 5.4.3-4.

Figure 5.4.3-3. NEHRP Soils in New York



Source: NYS DHSES, 2013

Note: The black circle indicates the approximate location of Suffolk County. The figure shows that the County's NEHRP soil classifications include B, C and D soils.

As illustrated in Figure 5.4.3-4, Suffolk County is primarily comprised of NEHRP soil classes B through D. The majority of the County is soil class D.

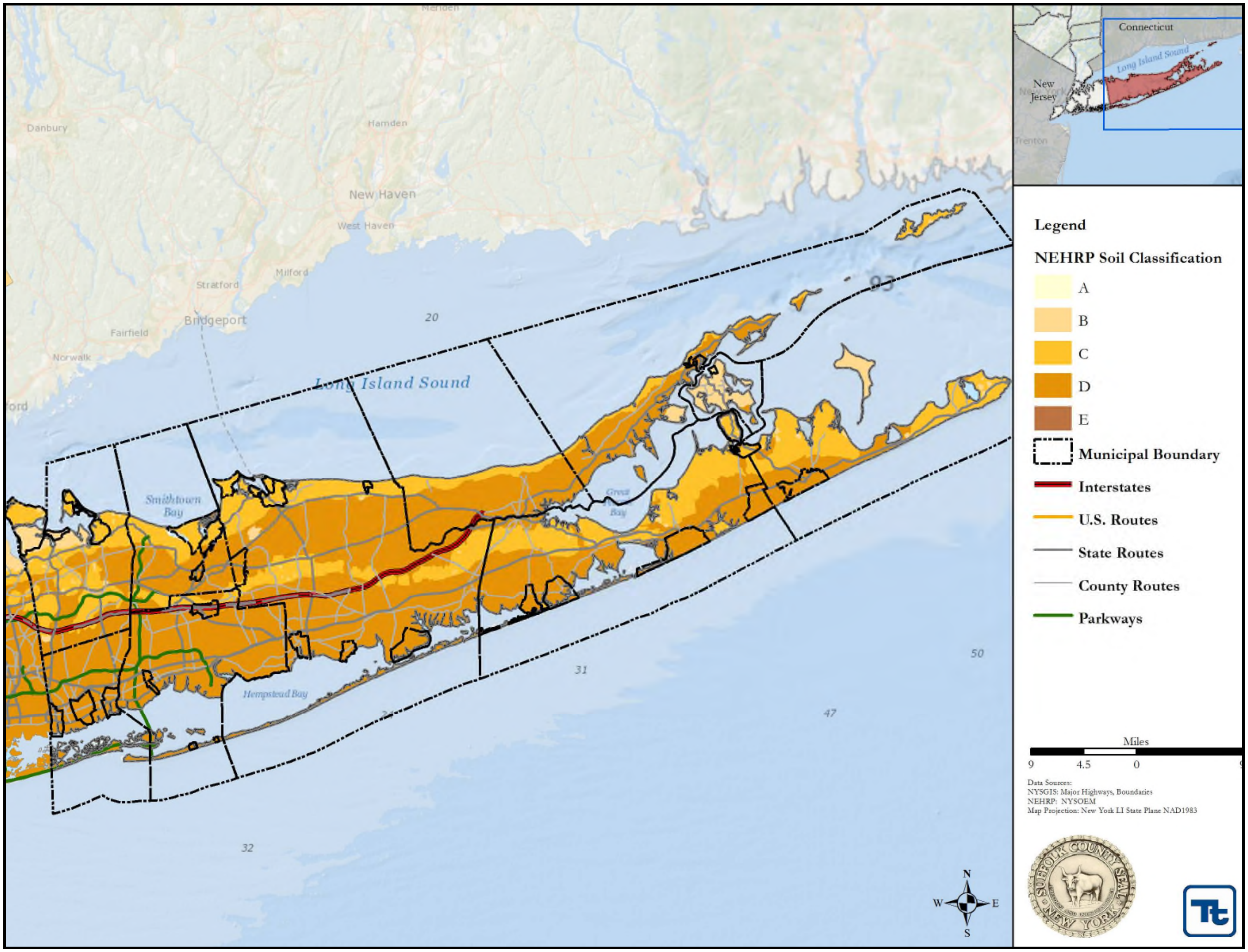
A probabilistic assessment was conducted for the 100-, 500- and 2,500-year mean return periods (MRP) through a Level 2 analysis in HAZUS-MH 2.1 to analyze the earthquake hazard for Suffolk County. The HAZUS analysis evaluates the statistical likelihood that a specific event will occur and what consequences will occur. A 100-year MRP event is an earthquake with a 1% chance that the mapped ground motion levels (PGA) will be exceeded in any given year. For a 500-year MRP, there is a 0.2% chance the mapped PGA will be exceeded in any given year. For a 2,500-year MRP, there is a 0.04% chance the mapped PGA will be exceeded in any given year. Figure 5.4.3-5 through Figure 5.4.3-7 illustrates the geographic distribution of PGA (*g*) across Suffolk County or 100-, 500- and 2,500-year MRP events at the Census-Tract level.

Table 5.4.3-4. NEHRP Soil Classifications

Soil Classification	Description
A	Very hard rock (e.g., granite, gneisses; and most of the Adirondack Mountains)
B	Rock (sedimentary) or firm ground
C	Stiff clay
D	Soft to medium clays or sands
E	Soft soil including fill, loose sand, waterfront, lake bed clays

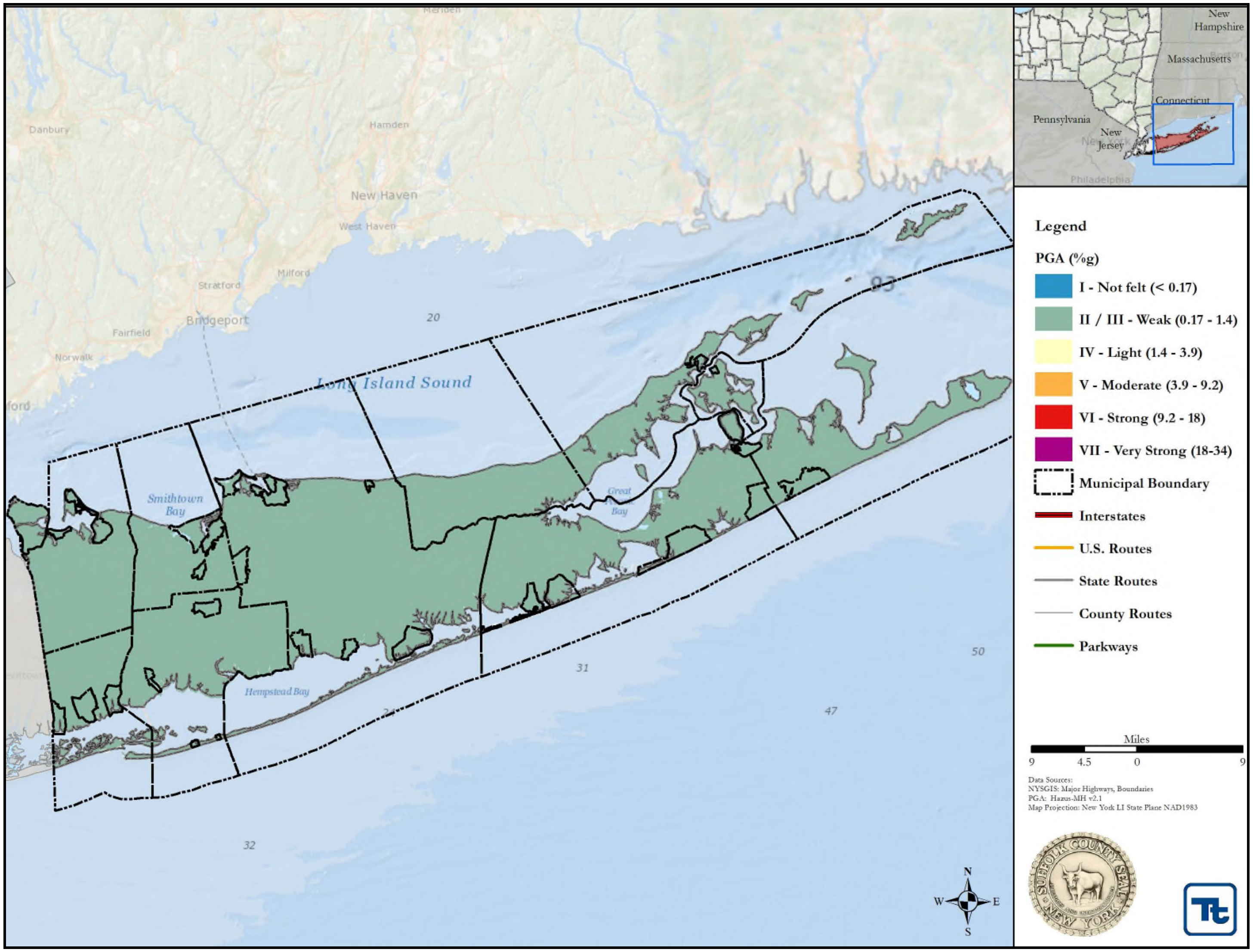
Source: NYS DHSES, 2013

Figure 5.4.3-4. NEHRP Soils in Suffolk County



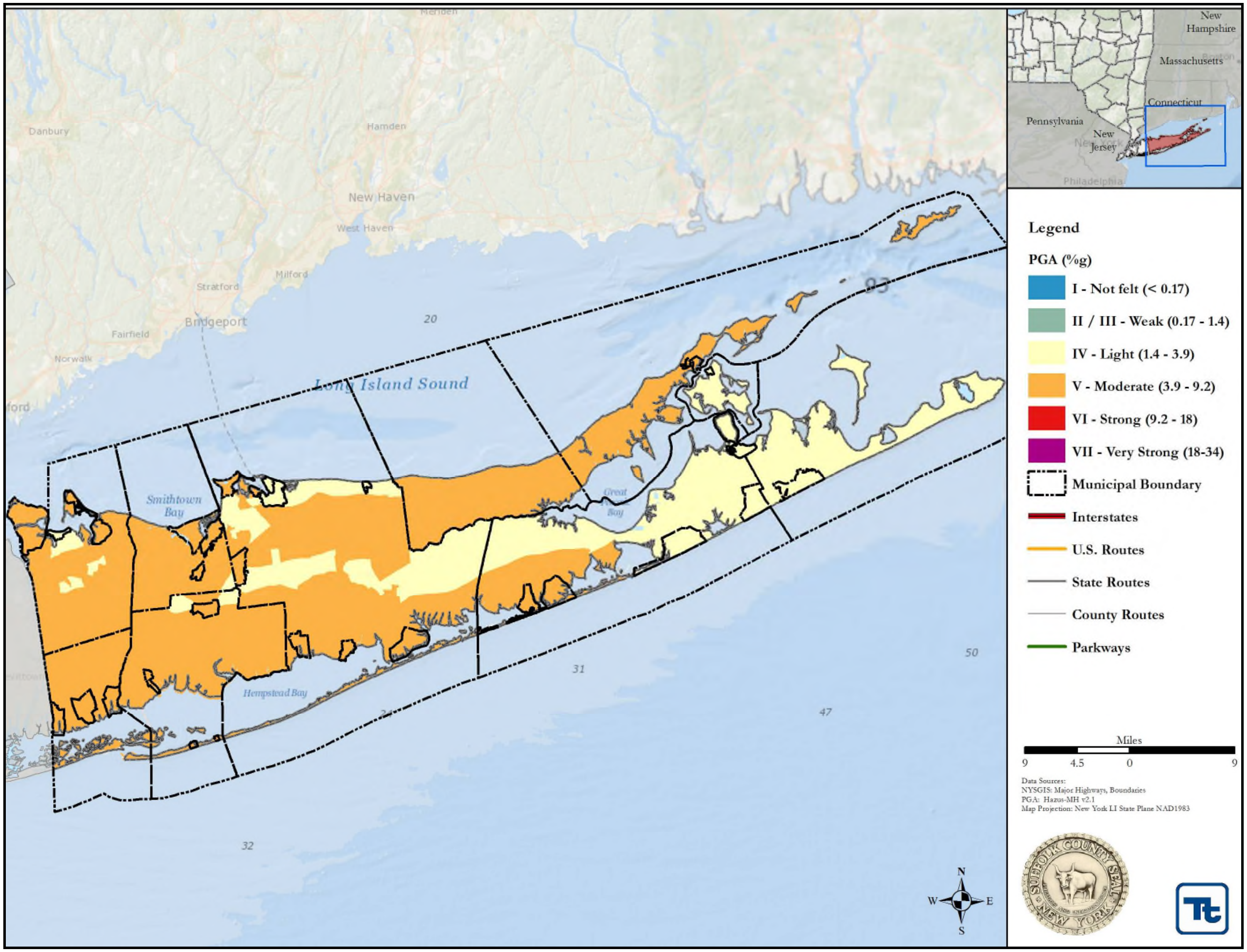
Source: NYSOEM, 2008

Figure 5.4.3-5. Peak Ground Acceleration Modified Mercalli Scale for a 100-Year MRP Earthquake Event



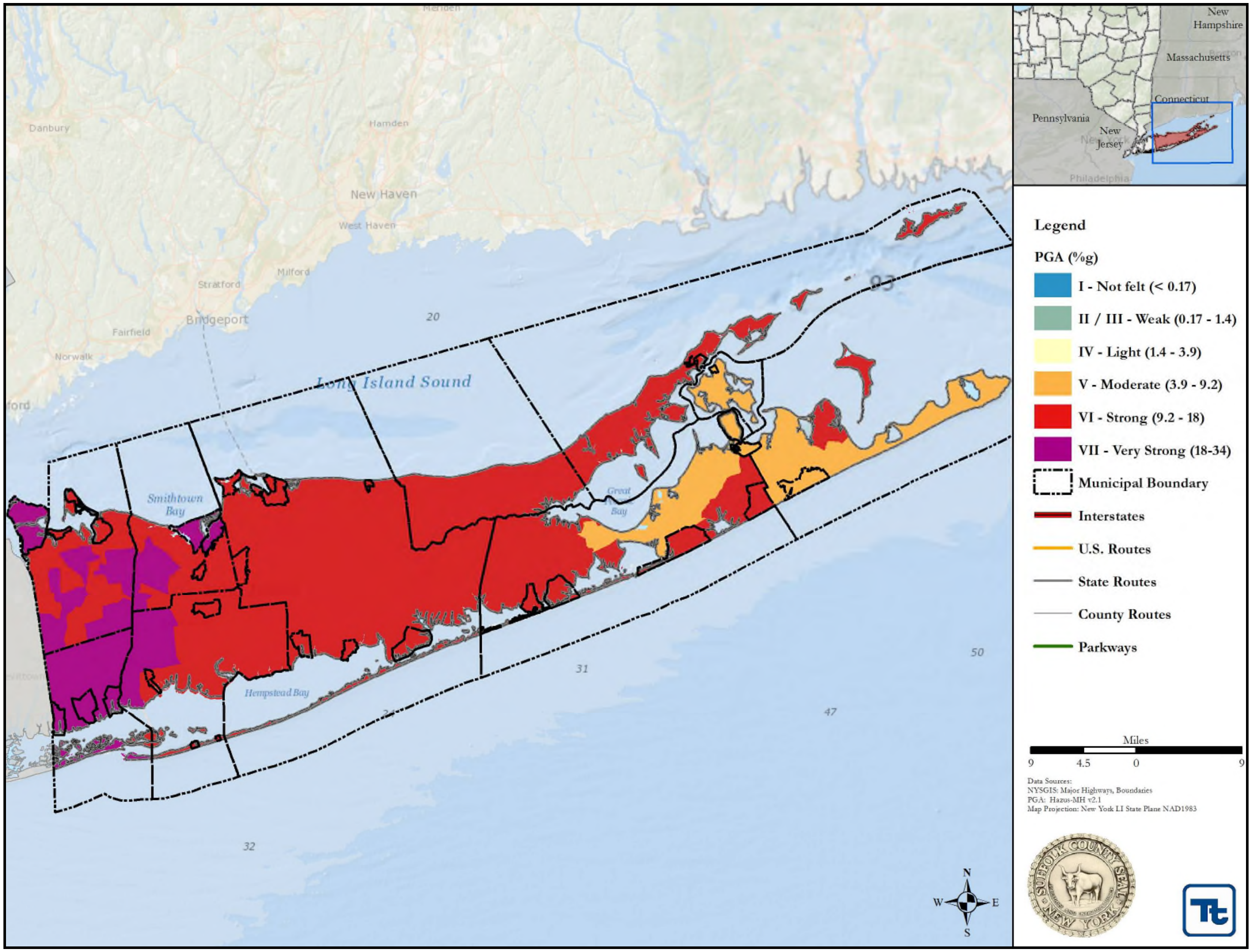
Source: *HAZUS-MH v2.1*
Note: *The peak ground acceleration for the 100-year MRP is 0.7 to 1.1 %g.*

Figure 5.4.3-6. Peak Ground Acceleration Modified Mercalli Scale for a 500-Year MRP Earthquake Event



Source: *HAZUS-MH v2.1*
Note: *The peak ground acceleration for the 500-year MRP is 2.5 to 5.7 %g*

Figure 5.4.3-7. Peak Ground Acceleration Modified Mercalli Scale for a 2,500-Year MRP Earthquake Event



Source: HAZUS-MH v2.1
Note: The peak ground acceleration for the 2,500-year MRP is 7.5 to 21.4 %g

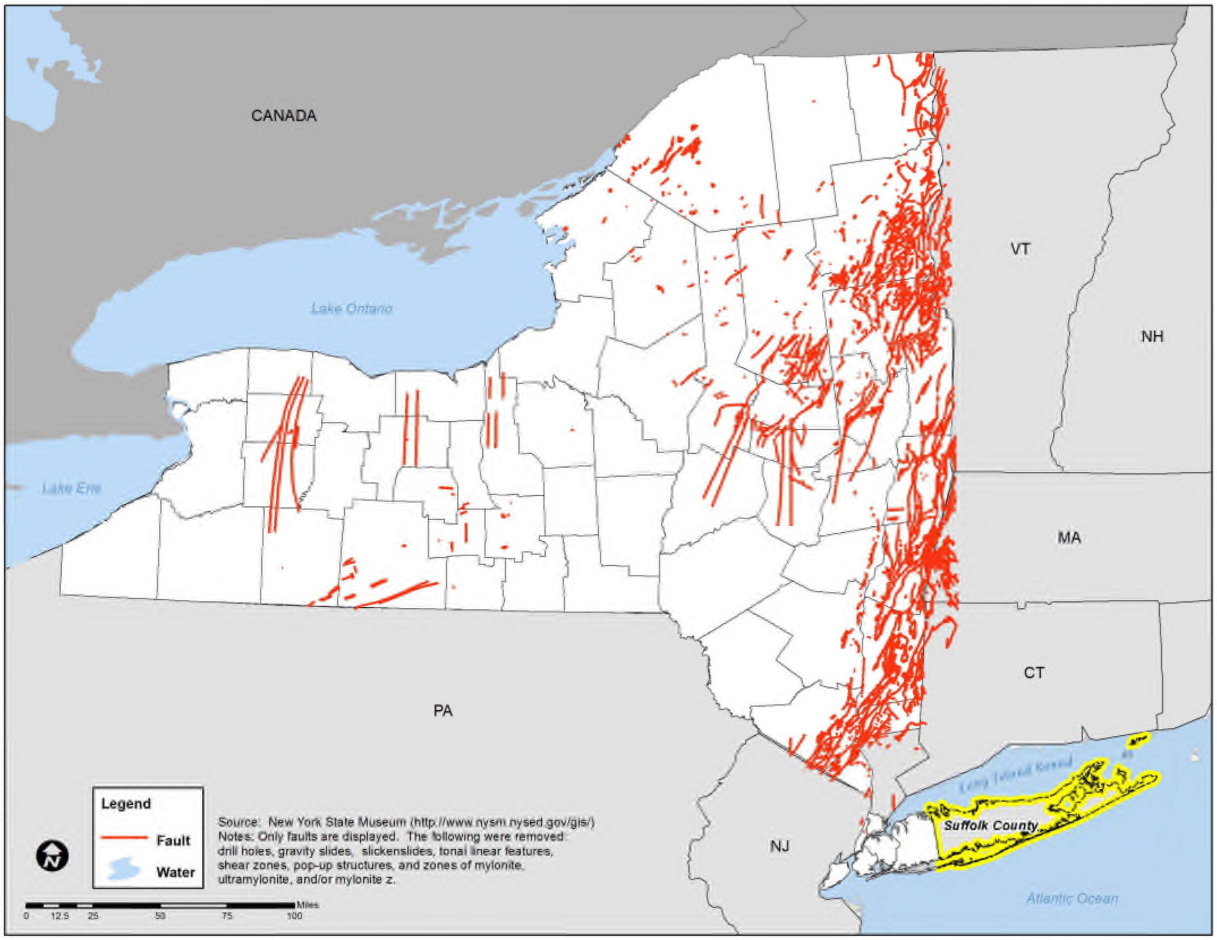
Location

As noted in the NYS HMP, the importance of the earthquake hazard in New York State is often underestimated because other natural hazards (for example, hurricanes and floods) occur more frequently and because major floods and hurricanes have occurred more recently than a major earthquake event (NYS DHSES, 2011). However, the potential for earthquakes exists across all of New York State and the entire northeastern U.S. The New York City Area Consortium for Earthquake Loss Mitigation (NYCEM) ranks New York State as having the third highest earthquake activity level east of the Mississippi River (Tantala et al., 2003).

The closest plate boundary to the East Coast is the Mid-Atlantic Ridge, which is approximately 2,000 miles east of Pennsylvania. Over 200 million years ago, when the continent Pangaea rifted apart forming the Atlantic Ocean, the Northeast coast of America was a plate boundary. Being at the plate boundary, many faults were formed in the region. Although these faults are geologically old and are contained in a passive margin, they act as pre-existing planes of weakness and concentrated strain. When a strain exceeds the strength of the ancient fault, it ruptures causing an earthquake (Lehigh Earth Observatory, 2006).

There are numerous faults throughout New York State. Figure 5.4.3-8 illustrates the faults relative to Suffolk County (New York State Museum, 2012).

Figure 5.4.3-8. Faults in New York State

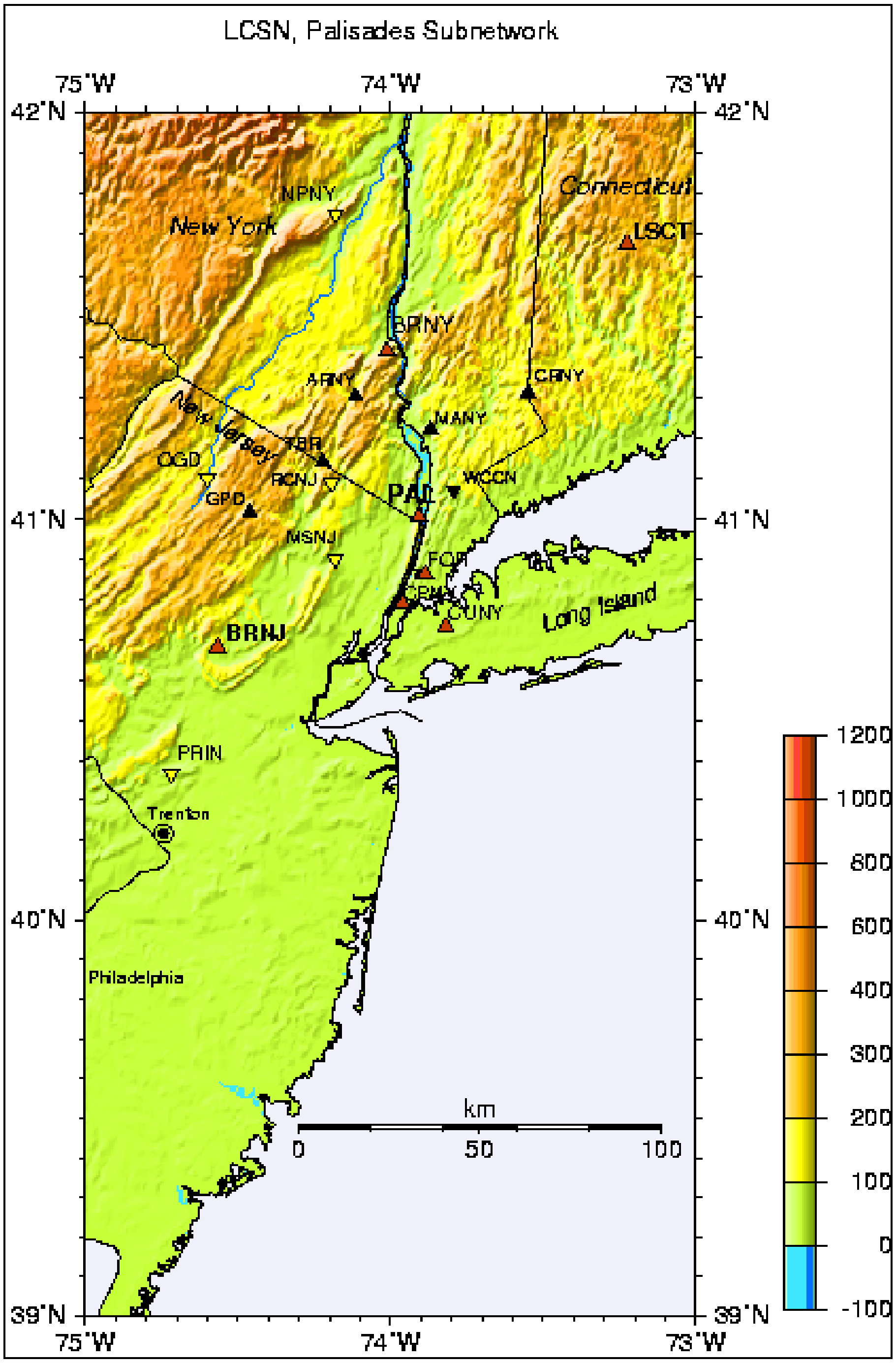


Source: New York State Museum, 2012

There are three general regions in New York State that have a higher seismic risk compared to other parts of the State. These regions are: 1) the north and northeast third of the State, which includes the North Country/Adirondack region and a portion of the greater Albany-Saratoga region; 2) the southeast corner, which includes the greater New York City area and western Long Island; and 3) the northwest corner, which includes Buffalo and its surrounding area. Overall, these three regions are the most seismically active areas of the State, with the north-northeast portion having the higher seismic risk and the northwest corner of the State has the lower seismic risk (NYS DHSES, 2011).

The Lamont-Doherty Cooperative Seismographic Network (LCSN) monitors earthquakes that occur primarily in the northeastern United States. The goal of the project is to compile a complete earthquake catalog for this region, to assess the earthquake hazards, and to study the causes of the earthquakes in the region. The LCSN operates 40 seismographic stations in the following seven states: Connecticut, Delaware, Maryland, New Jersey, New York, Pennsylvania, and Vermont. There are no seismic stations in Suffolk County; however, there are several within the vicinity of the County. Figure 5.4.3-9 shows the location of these stations in the New York and New Jersey area. The network of stations is composed of broadband and short-period seismographic stations (LCSN 2012).

Figure 5.4.3-9. Lamont-Doherty Seismic Stations Locations in the New York-New Jersey Area



Source: LCSN 2006

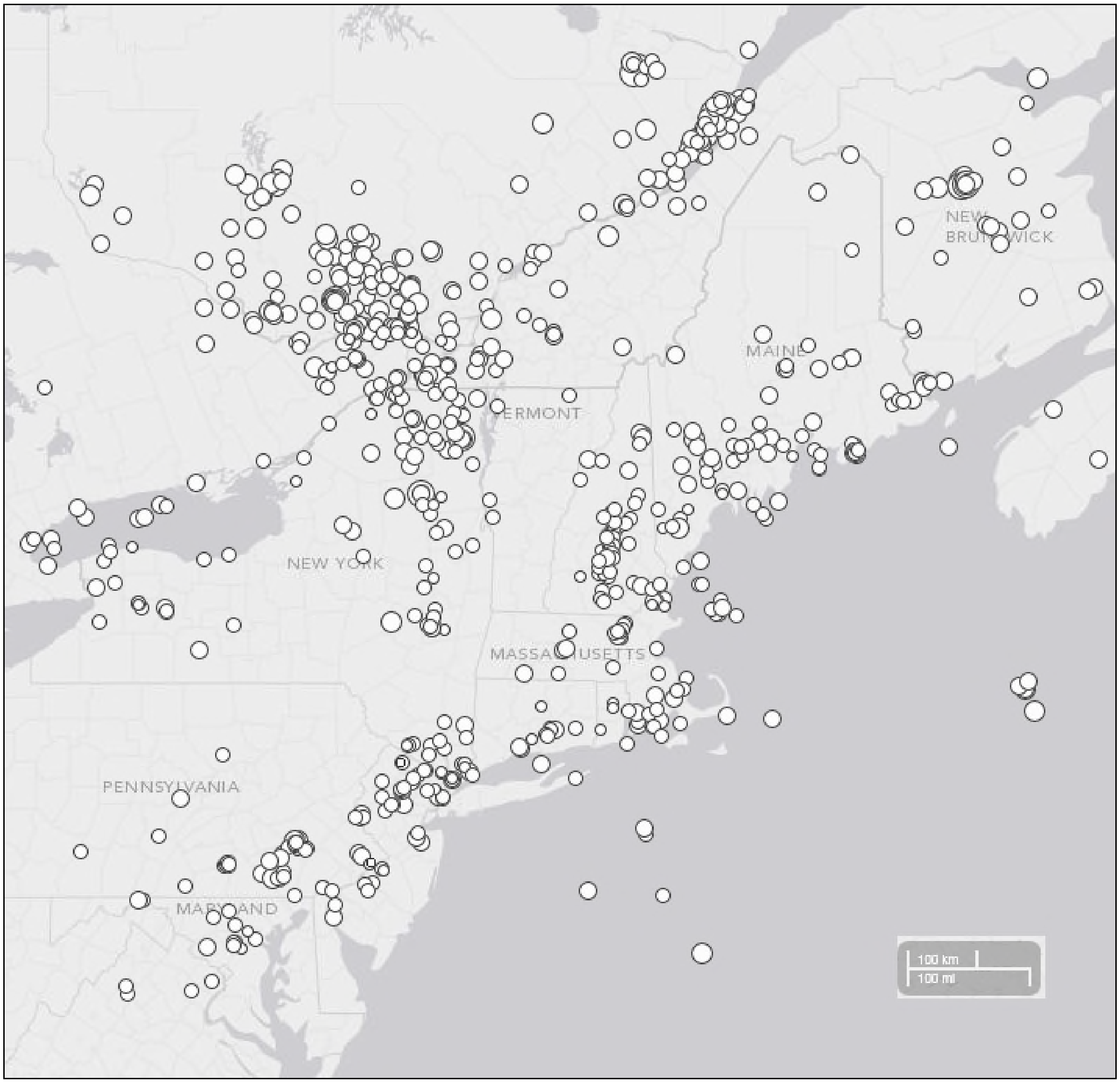
In addition to the Lamont-Doherty Seismic Stations, the USGS operates a global network of seismic stations to monitor seismic activity. While no seismic stations are located in New York State, nearby stations are positioned in State College, Pennsylvania and Oak Ridge, Massachusetts. Figure 5.4.3-X shows locations of USGS seismic stations near New York State.

Figure 5.4.3-10. USGS Seismic Stations near New York State

Source: USGS 2012

Figure 5.4.3-11 illustrates historic earthquake epicenters across the northeast U.S. and New York State between October 1975 and September 2013. There have been multiple earthquakes originating outside New York's borders that have been felt within the State. These quakes have come from Quebec, Canada and Massachusetts. According to the NYS HMP, such events are considered significant for hazard mitigation planning because they could produce damage within the State in certain situations.

Figure 5.4.3-11. Earthquake Epicenters in the Northeast U.S., October 1975 to September 2013



Source: USGS, 2013

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with earthquakes throughout New York State. Therefore, with so many sources reviewed for the purpose of this HMP, loss and impact information for many events could vary depending on the sources. According to the New York State 2014 HMP update, between 1973 and 2012, 189 earthquakes were epicentered in New York State. Of those 189 earthquakes, only one was reported in Suffolk County.

Between 1954 and 2013, New York State was included in one earthquake-related major disaster (DR) or emergency (EM) declaration. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declaration. Suffolk County was not included in any DRs or EMs (FEMA, 2013).

The 2007 Plan discussed earthquake events that occurred in Suffolk County from 1971 to 2007. For this 2014 plan update, earthquake events that occurred in Suffolk County between January 1, 2008 and present will be included. Based on all sources researched, known earhtuqkes events, between 2008 and 2013, that have affected Suffolk County and its municipalities are identified in Table 5.4.3-5. Not all sources have been identified or researched; therefore, Table 5.4.3-5 may not include all events that have occurred throughout the County and region. Events included in the 2007 Plan are provided in Appendix H.

Table 5.4.3-5. Earthquake Events in Suffolk County, 2008 to 2013

Dates of Event	Event Type	Location	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
February 27, 2008	Earthquake 2.7	Howes Cave, NY	N/A	N/A	No reference and/or no damage reported.	USGS
May 28, 2008	Earthquake 1.8	Saratoga Springs, NY	N/A	N/A	No reference and/or no damage reported.	USGS
February 18, 2009	Earthquake 2.3 – 2.7	East Berne, NY	N/A	N/A	No reference and/or no damage reported.	USGS
February 20, 2009	Earthquake 2.7	East Berne, NY	N/A	N/A	No reference and/or no damage reported.	USGS
February 23, 2009	Earthquake 2.1	East Berne, NY	N/A	N/A	No reference and/or no damage reported.	USGS
March 22, 2009	Earthquake 2.1 - 2.8	Berne, NY	N/A	N/A	No reference and/or no damage reported.	USGS
May 18, 2009	Earthquake 2.1 - 3.0	Berne, NY	N/A	N/A	No reference and/or no damage reported.	USGS
October 21, 2009	Earthquake 2.9	East Berne, NY	N/A	N/A	No reference and/or no damage reported.	USGS
December 13, 2009	Earthquake 2.6 – 3.1	Berne, NY	N/A	N/A	No reference and/or no damage reported.	USGS
February 15, 2010	Earthquake 2.2	Berne, NY	N/A	N/A	No reference and/or no damage reported.	USGS
February 18, 2010	Earthquake 2.7	Berne, NY	N/A	N/A	No reference and/or no damage reported.	USGS
March 24, 2010	Earthquake 2.7	Berne, NY	N/A	N/A	No reference and/or no damage reported.	USGS
June 23, 2010	Earthquake 5.5	Ontario and Quebec, Canada border	N/A	N/A	A minor earthquake in Canada was felt throughout the New York City and upstate New York area. The earthquake lasted about 30 seconds. Tremors were felt in the City of Binghamton.	NY1News

Dates of Event	Event Type	Location	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
August 23, 2011	Earthquake 5.9	Virginia	N/A	N/A	An earthquake centered in Virigina was felt up and down the east coast. Many residents across Long Island, including in Suffolk County, said they felt the earthquake.	Bolger, Rumsey, Mian, and Christ, 2011
August 25, 2011	Earthquake 2.0 – 2.8	Altamont, NY	N/A	N/A	No reference and/or no damage reported.	USGS
August 26, 2011	Earthquake 2.2	Altamont, NY	N/A	N/A	No reference and/or no damage reported.	USGS
August 27, 2011	Earthquake 2.9	Altamont, NY	N/A	N/A	No reference and/or no damage reported.	USGS
November 21, 2011	Earthquake 2.4	Moira, NY	N/A	N/A	No reference and/or no damage reported.	USGS
January 7, 2012	Earthquake 2.1	Bombay, NY	N/A	N/A	No reference and/or no damage reported.	USGS
January 23, 2012	Earthquake 2.3	Johnsburg, NY	N/A	N/A	No reference and/or no damage reported.	USGS
March 23, 2012	Earthquake 2.5	Mt. Morris, NY	N/A	N/A	No reference and/or no damage reported.	USGS
September 7, 2012	Earthquake 2.1	Greenwich, CT	N/A	N/A	No reference and/or no damage reported.	USGS
October 26, 2012	Earthquake 2.5	Newfane, NY	N/A	N/A	No reference and/or no damage reported.	USGS
November 5, 2012	Earthquake 2.1	Ringwood, NJ	N/A	N/A	No reference and/or no damage reported.	USGS
January 16, 2013	Earthquake 2.4	Malone, NY	N/A	N/A	No reference and/or no damage reported.	USGS
February 16, 2013	Earthquake 1.8	Broadalbin, NY	N/A	N/A	No reference and/or no damage reported.	USGS
February 26, 2013	Earthquake 2.0	Malone, NY	N/A	N/A	No reference and/or no damage reported.	USGS

Dates of Event	Event Type	Location	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
March 7, 2013	Earthquake 2.2	Altamont, NY	N/A	N/A	No reference and/or no damage reported.	USGS
March 13, 2013	Earthquake 2.3	Newcomb, NY	N/A	N/A	No reference and/or no damage reported.	USGS
March 17, 2013	Earthquake 1.6	Newcomb, NY	N/A	N/A	No reference and/or no damage reported.	USGS
April 1, 2013	Earthquake 1.7	Brownville, NY	N/A	N/A	No reference and/or no damage reported.	USGS
April 4, 2013	Earthquake 1.8	Hope Valley, RI	N/A	N/A	No reference and/or no damage reported.	USGS
April 18, 2013	Earthquake 2.1	Kinnelon, NJ	N/A	N/A	No reference and/or no damage reported.	USGS
April 20, 2013	Earthquake 1.9	Medina, NY	N/A	N/A	No reference and/or no damage reported.	USGS
May 1, 2013	Earthquake 1.2	Norwood, NY	N/A	N/A	No reference and/or no damage reported.	USGS
May 2, 2013	Earthquake 1.5	Newcomb, NY	N/A	N/A	No reference and/or no damage reported.	USGS
May 16, 2013	Earthquake 1.4	Attica, NY	N/A	N/A	No reference and/or no damage reported.	USGS
June 23, 2013	Earthquake 2.1	Rockaway, NJ	N/A	N/A	No reference and/or no damage reported.	USGS
July 20, 2013	Earthquake 1.4	Massena, NY	N/A	N/A	No reference and/or no damage reported.	USGS
July 27, 2013	Earthquake 2.0	Utica, NY	N/A	N/A	No reference and/or no damage reported.	USGS
August 25, 2013	Earthquake 2.7	Hadley, NY	N/A	N/A	No reference and/or no damage reported.	USGS

Dates of Event	Event Type	Location	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
August 27, 2013	Earthquake 2.0	Malone, NY	N/A	N/A	No reference and/or no damage reported.	USGS
September 9, 2013	Earthquake 2.0	Dundee, NY	N/A	N/A	No reference and/or no damage reported.	USGS

Source(s): NYS DHSES, 2011; USGS, 2013; Kim, 1999; Stover and Coffman, 1989

DR	Disaster Declaration	NEIC	National Earthquake Information Center
FEMA	Federal Emergency Management Agency	NYSDPC	New York State Disaster Preparedness Commission
N/A	Not Applicable	USGS	U.S. Geological Survey

Earthquakes in Suffolk County are not common, with documented information on earthquake events and their location is being relatively scarce. According to the USGS, there has been only one earthquake with its epicenter in the County. It had a magnitude of 2.8 and occurred on March 10, 1992. However, depending on the magnitude, the impacts of earthquake events can be far-reaching; therefore, reported incidences within the surrounding counties or states could have created indirect impacts upon the County.

Probability of Future Events

Earthquake hazard maps illustrate the distribution of earthquake shaking levels that have a certain probability of occurring over a given time period. According to the USGS, in 2008 (the date of the most recent analysis), Suffolk County had a PGA of 2-3%g for earthquakes with a 10-percent probability of occurring within 50 years.

The NYSDPC indicates that the earthquake hazard in New York State is often understated because other natural hazards occur more frequently (for example: hurricanes, tornadoes and flooding) and are much more visible. However, the potential for earthquakes does exist across the entire northeastern U.S., and New York State is no exception (NYS DHSES, 2011).

Earlier in this section, the identified hazards of concern for Suffolk County were ranked. NYSOEM conducts a similar ranking process for hazards that affect the State. The probability of occurrence, or likelihood of the event, is one parameter used for ranking hazards. Based on historical records and input from the Planning Committee, the probability of occurrence for earthquakes in the County is considered “rare” (not likely to occur within 100 years as presented in Table 5.3-3). Although no reported incidences have occurred within Suffolk County, it is anticipated that the County will experience indirect impacts from earthquakes that may affect the general building stock, local economy and may induce secondary hazards such ignite fires and cause utility failure.

Climate Change

The impacts of global climate change on earthquake probability are unknown. Some scientists say that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the earth’s crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. NASA and USGS scientists found that retreating glaciers in southern Alaska may be opening the way for future earthquakes (NASA, 2004).

Secondary impacts of earthquakes could be magnified by climate change. Soils saturated by repetitive storms could experience liquefaction during seismic activity due to the increased saturation. Dams storing increased volumes of water due to changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts.

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For the earthquake hazard, the entire County has been identified as the exposed hazard area. Therefore, all assets in Suffolk County (population, structures, critical facilities and lifelines), as described in the County Profile (Section 4), are vulnerable. The following section includes an evaluation and estimation of the potential impact of the earthquake hazard on Suffolk County including the following:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, health and safety of residents, (2) general building stock, (3) critical facilities, (4) economy, and (5) future growth and development
- Effect of climate change on vulnerability
- Change of vulnerability as compared to that presented in the 2008 Suffolk County Hazard Mitigation Plan
- Further data collections that will assist understanding this hazard over time

Overview of Vulnerability

Earthquakes usually occur without warning and can impact areas a great distance from their point of origin. The extent of damage depends on the density of population and building and infrastructure construction in the area shaken by the quake. Some areas may be more vulnerable than others based on soil type, the age of the buildings and building codes in place. Compounding the potential for damage – historically, Building Officials Code Administration (BOCA) used in the Northeast were developed to address local concerns including heavy snow loads and wind; seismic requirements for design criteria are not as stringent compared to the west coast's reliance on the more seismically-focused Uniform Building Code). As such, a smaller earthquake in the Northeast can cause more structural damage than if it occurred out west.

The entire population and general building stock inventory of the County is at risk of being damaged or experiencing losses due to impacts of an earthquake. Potential losses associated with the earth shaking were calculated for Suffolk County for three probabilistic earthquake events, the 100-year, 500- and 2,500-year mean return periods (MRP). The impacts on population, existing structures, critical facilities and the economy within Suffolk County are presented below, following a summary of the data and methodology used.

Data and Methodology

A probabilistic assessment was conducted for Suffolk County for the 100-, 500- and 2,500-year MRPs through a Level 2 analysis in HAZUS-MH 2.1 to analyze the earthquake hazard and provide a range of loss estimates for Suffolk County. The probabilistic method uses information from historic earthquakes and inferred faults, locations and magnitudes, and computes the probable ground shaking levels that may be experienced during a recurrence period by Census tract. According to the New York City Area Consortium for Earthquake Loss Mitigation (NYCEM), probabilistic estimates are best for urban planning, land use, zoning and seismic building code regulations (NYCEM, 2003). The default assumption is a magnitude 7 earthquake for all return periods. In addition, an annualized loss run was also conducted in HAZUS-MH 2.1 to estimate the annualized general building stock dollar losses for Suffolk County.

Ground shaking is the primary cause of earthquake damage to man-made structures and soft soils amplify ground shaking. One contributor to the site amplification is the velocity at which the rock or soil transmits shear waves (S-waves). The NEHRP developed five soil classifications defined by their shear-wave velocity that impact the severity of an earthquake. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses.

As illustrated in Figure 5.4.7-3, Suffolk County is made up of dense soil/soft rock (C), stiff/soft soils (D) with a small area of soft soils (E) in the northeastern portion of the County. When unchanged, HAZUS-MH default soil types are class "D". However, for this analysis HAZUS-MH was updated with the specific NEHRP soil types for Suffolk County as provided by NYSOEM.

In addition to the probabilistic scenarios mentioned, an annualized loss run was conducted in HAZUS 2.1 to estimate the annualized general building stock dollar losses for the County. The annualized loss methodology combines the estimated losses associated with ground shaking for eight return periods: 100, 250, 500, 750, 1000, 1500, 2000, 2500-year, which are based on values from the USGS seismic probabilistic curves. Annualized losses are useful for mitigation planning because they provide a baseline upon which to 1) compare the risk of one hazard across multiple jurisdictions and 2) compare the degree of risk of all hazards for each participating jurisdiction.

As noted in the HAZUS-MH Earthquake User Manual '*Uncertainties are inherent in any loss estimation methodology. They arise in part from incomplete scientific knowledge concerning earthquakes and their effects upon buildings and facilities. They also result from the approximations and simplifications that are necessary for comprehensive analyses. Incomplete or inaccurate inventories of the built environment, demographics and economic parameters add to the uncertainty. These factors can result in a range of uncertainly in loss estimates produced by the HAZUS Earthquake Model, possibly at best a factor of two or more*.' However, HAZUS' potential loss estimates are acceptable for the purposes of this HMP.

The occupancy classes available in HAZUS-MH 2.1 were condensed into the following categories (residential, commercial, industrial, agricultural, religious, government, and educational) to facilitate the analysis and the presentation of results. Residential loss estimates address both multi-family and single family dwellings. Impacts to critical facilities and utilities were also evaluated.

Data used to assess this hazard include data available in the HAZUS-MH 2.1 earthquake model, USGS data, data provided by NYSOEM, professional knowledge, and information provided by the County's Planning Committee.

Impact on Life, Health and Safety

Overall, the entire population of Suffolk County is exposed to the earthquake hazard event. The impact of earthquakes on life, health and safety is dependent upon the severity of the event. Risk to public safety and loss of life from an earthquake in Suffolk County is minimal with higher risk occurring in buildings as a result of damage to the structure, or people walking below building ornamentation and chimneys that may be shaken loose and fall as a result of the quake.

Populations considered most vulnerable are those located in/near the built environment, particularly near unreinforced masonry construction. In addition, the vulnerable population includes the elderly (persons over the age of 65) and individuals living below the Census poverty threshold. These socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Refer to Section 4 (County Profile) for the vulnerable population statistics in Suffolk County.

Residents may be displaced or require temporary to long-term sheltering due to the event. The number of people requiring shelter is generally less than the number displaced as some displaced persons use hotels or stay with family or friends following a disaster event. Table 5.4.3-6 summarizes the households HAZUS-MH 2.1 estimates will be displaced and population that may require short-term sheltering as a result of the 100-, 500- and 2,500-year MRP earthquake events.

Table 5.4.3-6. Summary of Estimated Sheltering Needs for Suffolk County

Scenario	Displaced Households	Persons Seeking Short-Term Shelter
100-Year Earthquake	0	0
500-Year Earthquake	56	37
2,500-Year Earthquake	1,023	690

Source: HAZUS-MH 2.1

In HAZUS-MH, estimated sheltering needs are summarized at the Census tract level. The Census tracts do not exactly align with municipal boundaries; therefore, a total is reported for each Town inclusive of the Villages and the Tribes within its boundary. Table 5.4.3-7 summarizes the population HAZUS-MH estimates will be displaced or will require short-term sheltering for the 100-, 500- and 2,500-year MRP by Town.

Table 5.4.3-7. Estimated Displaced Households and Population Seeking Short-Term Shelter from the 500- and 2,500-year MRP Events by Town

Town	100-Year MRP		500-Year MRP		2,500-Year MRP	
	Displaced Households	People Requiring Short-Term Shelter	Displaced Households	People Requiring Short-Term Shelter	Displaced Households	People Requiring Short-Term Shelter
Babylon (T)	0	0	14	10	276	193
Brookhaven (T)	0	0	15	10	271	177
East Hampton (T)	0	0	0	0	4	2
Huntington (T)	0	0	7	4	127	79
Islip (T)	0	0	12	9	227	169
Riverhead (T)	0	0	1	1	18	11
Shelter Island (T)	0	0	0	0	0	0
Smithtown (T)	0	0	4	2	74	43
Southampton (T)	0	0	1	1	16	10
Southold (T)	0	0	1	0	10	6
Suffolk County	**0**	**0**	**56**	**37**	**1,023**	**690**

Source: HAZUS-MH 2.1
Note: The number of displaced households and persons seeking shelter was calculated using the 2000 U.S. Census data (HAZUS-MH 2.1 default demographic data).
In HAZUS-MH, the earthquake analysis is conducted at the Census tract level. The Census tracts do not exactly align with municipal boundaries; therefore, a total is reported for each Town inclusive of the Villages and the Tribes within its boundary.
Census Tract 36103147002 includes both a portion of the Town of Babylon and the Town of Islip. For this analysis, Census Tract 36103147002 was included as part of the Town of Islip.
Census Tract 36103190708 is located in the Town of Southampton. Please note that half of the Village of Sag Harbor is included in this Tract.

According to the 1999-2003 NYCEM Summary Report (*Earthquake Risks and Mitigation in the New York / New Jersey / Connecticut Region*), there is a strong correlation between structural building damage and the number of injuries and casualties from an earthquake event. Further, the time of day also exposes different sectors of the community to the hazard. For example, HAZUS considers the residential occupancy at its maximum at 2:00 a.m., where the educational, commercial and industrial sectors are at their maximum at 2:00 p.m., and peak commute time is at 5:00 p.m. Whether directly impacted or indirectly impact, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself.

There are no injuries or casualties estimated for the 100-year event. Table 5.4.3-8 and Table 5.4.3-9 summarizes the County-wide injuries and casualties estimated for the 500- and 2,500-year MRP earthquake events, respectively.

Table 5.4.3-8. Estimated Number of Injuries and Casualties from the 2,500-Year MRP Earthquake Event

Level of Severity	Time of Day		
	2:00 AM	2:00 PM	5:00 PM
Injuries	47	41	38
Hospitalization	5	5	4
Casualties	1	1	1

Source: HAZUS-MH 2.1

Table 5.4.3-9. Estimated Number of Injuries and Casualties from the 2,500-Year MRP Earthquake Event

Level of Severity	Time of Day		
	2:00 AM	2:00 PM	5:00 PM
Injuries	547	582	523
Hospitalization	88	103	102
Casualties	15	18	17

Source: HAZUS-MH 2.1

Impact on General Building Stock

After considering the population vulnerable to the earthquake hazard, the value of general building stock exposed to and damaged by 100-, 500- and 2,500-year MRP earthquake events was evaluated. In addition, annualized losses were calculated using HAZUS-MH 2.1. The entire County's general building stock is considered at risk and exposed to this hazard.

The HAZUS-MH 2.1 model estimates the value of the exposed building stock and the loss (in terms of damage to the exposed stock). Refer to the County Profile (Section 4) for general building stock data replacement value statistics (structure and contents).

For this plan update and using HAZUS-MH 2.1, a probabilistic model was run to estimate annualized dollar losses for Suffolk County. Annualized losses are useful for mitigation planning because they provide a baseline upon which to 1) compare the risk of one hazard across multiple jurisdictions and 2) compare the degree of risk of all hazards for each participating jurisdiction. Please note that annualized loss does not predict what losses will occur in any particular year. The estimated annualized losses are approximately $8.5 million per year (building and contents) for the County.

According to NYCEM, where earthquake risks and mitigation were evaluated in the New York, New Jersey and Connecticut region, most damage and loss caused by an earthquake is directly or indirectly the result of ground shaking (NYCEM, 2003). NYCEM indicates there is a strong correlation between PGA and the damage a building might experience. The HAZUS-MH model is based on the best available earthquake science and aligns with these statements. HAZUS-MH 2.1 methodology and model were used to analyze the earthquake hazard for the general building stock for Suffolk County. See Figure 5.4.3-5 through Figure 5.4.3-7 earlier in this profile that illustrates the geographic distribution of PGA (g) across the County for 100-, 500- and 2,500-year MRP events at the Census-tract tevel.

In addition, according to NYCEM, a building's construction determines how well it can withstand the force of an earthquake. The NYCEM report indicates that un-reinforced masonry buildings are most at risk during an earthquake because the walls are prone to collapse outward, whereas steel and wood buildings absorb more of the earthquake's energy. Additional attributes that contribute to a building's capability to withstand an earthquake's force include its age, number of stories and quality of construction. HAZUS-MH considers building construction and the age of buildings as part of the analysis.

Potential building damage was evaluated by HAZUS-MH 2.1 across the following damage categories (none, slight, moderate, extensive and complete). Table 5.4.3-10 provides definitions of these five categories of damage for a light wood-framed building; definitions for other building types are included in HAZUS-MH technical manual documentation. General building stock damage for these damage categories by occupancy class and building type on a County-wide basis is summarized below for the 100-, 500- and 2,500-year events.

Table 5.4.3-10. Example of Structural Damage State Definitions for a Light Wood-Framed Building

Damage Category	Description
Slight	Small plaster or gypsum-board cracks at corners of door and window openings and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer.
Moderate	Large plaster or gypsum-board cracks at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by small cracks in stucco and gypsum wall panels; large cracks in brick chimneys; toppling of tall masonry chimneys.
Extensive	Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations; partial collapse of room-over-garage or other soft-story configurations.
Complete	Structure may have large permanent lateral displacement, may collapse, or be in imminent danger of collapse due to cripple wall failure or the failure of the lateral load resisting system; some structures may slip and fall off the foundations; large foundation cracks.

Source: HAZUS-MH Technical Manual

HAZUS-MH 2.1 estimates $0 in damage to Suffolk County's general building stock as a result of a 100-year MRP event. Table 5.4.3-11 through Table 5.4.3-16 summarizes the damage estimated for the 100-, 500- and 2,500-year MRP earthquake events. Damage loss estimates include structural and non-structural damage to the building and loss of contents.

Table 5.4.3-11. Estimated Buildings Damaged by General Occupancy for 500-year and 2,500-year MRP Earthquake Events

Category	Average Damage State									
	500-Year MRP					2,500-Year MRP				
	None	Slight	Moderate	Extensive	Complete	None	Slight	Moderate	Extensive	Complete
Residential	89.6%	<1%	<%	<1%	<1%	74.9%	12.5%	3.9%	<1%	<1%
Commercial	3.9%	<1%	<1%	<1%	<1%	3%	<1%	<1%	<1%	<1%
Industrial	<1%	<1%	<1%	<1%	<1%	1.7%	<1%	<1%	<1%	<1%
Education, Government, Religious and Agricultural	1.6%	<1%	<1%	<1%	<1%	1.3%	<1%	<1%	<1%	<1%

Source: HAZUS-MH 2.1
Note: Based on an inventory of 617,430 buildings in HAZUS-MH. HAZUS-MH does not estimate building damages as a result of a 100-year MRP event.

Table 5.4.3-12. Estimated Number of Buildings Damaged by Building Type for 500-year and 2,500-year MRP Earthquake Events

Category	Average Damage State									
	500-Year MRP					2,500-Year MRP				
	None	Slight	Moderate	Extensive	Complete	None	Slight	Moderate	Extensive	Complete
Wood	77	1.2	<1	<1	0	65.5	10.2	<1	<1	<1
Steel	3.9	<1	<1	<1	0	<1	<1	<1	<1	<1
Concrete	1.7	<1	<1	<1	0	<1	<1	<1	<1	<1
Reinforced Masonry	<1	<1	<1	<1	0	<1	<1	<1	<1	<1
Un-reinforced Masonry	13.6	<1	<1	<1	<1	10.1	1.5	<1	<1	<1
Manufactured housing	<1	<1	<1	<1	0	<1	<1	<1	<1	<1

Source: HAZUS-MH 2.1
Note: Based on an inventory of 617,430 buildings in HAZUS-MH. HAZUS-MH does not estimate building damages as a result of a 100-year MRP event.

Table 5.4.3-13. Estimated Building Value (Building and Contents) Damaged by the 500- and 2,500-Year MRP Earthquake Events

Town	Estimated Total Damages*			Percent of Total Building and Contents RV**		Estimated Residential Damage		Estimated Commercial Damage	
	Annualized Loss	500-Year	2,500-Year	500-Year	2,500-Year	500-Year	2,500-Year	500-Year	2,500-Year
Babylon (T)	$1,390,174	$75,419,706	$1,332,846,454	0.1	1.6	$34,770,096	$584,862,931	$9,719,685	$259,127,237
Brookhaven (T)	$2,095,194	$128,618,913	$2,065,631,997	0.1	1.0	$92,814,277	$1,450,991,996	$18,100,844	$527,639,596
East Hampton (T)	$71,994	$5,170,138	$73,580,755	0.0	0.4	$4,363,570	$60,010,701	$548,169	$17,214,889
Huntington (T)	$1,250,352	$70,139,810	$1,240,131,901	0.1	1.3	$40,670,849	$701,593,685	$19,097,897	$406,724,470
Islip (T)	$1,677,736	$96,087,975	$1,637,521,453	0.1	1.4	$60,039,003	$985,596,500	$21,667,287	$499,386,668
Riverhead (T)	$226,678	$13,398,647	$204,013,353	0.1	1.0	$6,414,622	$89,801,170	$3,690,415	$60,926,894
Shelter Island (T)	$5,821	$379,349	$6,600,243	0.0	0.2	$331,401	$5,643,676	$33,115	$1,383,294
Smithtown (T)	$940,988	$53,909,841	$953,595,152	0.1	1.2	$39,916,221	$670,731,716	$6,620,112	$236,690,341
Southampton (T)	$324,408	$23,645,311	$312,044,365	0.0	0.6	$19,767,559	$255,039,255	$2,628,981	$75,453,477
Southold (T)	$144,197	$9,672,312	$132,448,586	0.1	0.8	$6,768,787	$88,402,691	$1,533,472	$33,959,948
Suffolk County	**$8,127,542**	**$476,442,003**	**$7,958,414,258**	**0.1**	**1.1**	**$305,856,386**	**$4,892,674,321**	**$83,639,977**	**$2,118,506,814**

Source: HAZUS-MH 2.1
**Total Damages is sum of damages for all occupancy classes (residential, commercial, industrial, agricultural, educational, religious and government).*
RV Replacement Value

It is estimated that there would be nearly $500 million in damages to buildings in the County during a 500-year earthquake event. This includes structural damage, non-structural damage and loss of contents, representing less than one-percent of the total replacement value for general building stock in Suffolk County. For a 2,500-year MRP earthquake event, HAZUS-MH estimates greater than $8 billion, approximately one-percent of the total general building stock replacement value. Residential and commercial buildings account for most of the damage for earthquake events.

Earthquakes can cause secondary hazard events such as fires. No fires are anticipated as a result of the 100-year MRP event. There is one fire estimated as a result of the 500-year event that will displace approximately 44 people and cause approximately $5 million in building damage. There is one fire estimated as a result of the 2,500-year event that will displace approximately 341 people and cause an estimated $47 million in damages.

Impact on Critical Facilities

After considering the general building stock exposed to, and damaged by, 100-, 500- and 2,500-year MRP earthquake events, critical facilities were evaluated. All critical facilities (essential facilities, transportation systems, lifeline utility systems, high-potential loss facilities and user-defined facilities) in Suffolk County are considered exposed and vulnerable to the earthquake hazard. Refer to subsection "Critical Facilities" in Section 4 (County Profile) of this Plan for a complete inventory of critical facilities in the County.

HAZUS-MH 2.1 estimates the probability that critical facilities may sustain damage as a result of 100-, 500- and 2,500-year MRP earthquake events. Additionally, HAZUS-MH estimates percent functionality for each facility days after the event. As a result of a 100-Year MRP event, HAZUS-MH 2.1 estimates that emergency facilities (police, fire, EMS and medical facilities), schools and specific facilities identified by Suffolk County as critical will not experience any structural damage. These facilities are estimated to be nearly 100% functional on day one of the 100-year MRP earthquake event. Therefore, the impact to critical facilities is not significant for the 100-year event.

Table 5.4.3-14 through Table 5.4.3-16 list the percent probability of critical facilities sustaining the damage category as defined by the column heading and percent functionality after the event for the 500-year and 2,500-year MRP earthquake events.

Table 5.4.3-14. Estimated Damage and Loss of Functionality for Critical Facilities and Utilities in Suffolk County for the 500-Year MRP Earthquake Event

Name	Percent Probability of Sustaining Damage					Percent Functionality			
	None	Slight	Moderate	Extensive	Complete	Day 1	Day 7	Day 30	Day 90
Critical Facilities									
EOC	98-100	<1-1.5	<1	0	0	98-100	99 - 100	99 - 100	99 - 100
Medical	98-100	<1-1.5	<1	0	0	98-100	99 - 100	99 - 100	99 - 100
Police	98-100	<1-1.5	<1	0	0	98-100	99 - 100	99 - 100	99 - 100
Fire	98-100	<1-1.5	<1	0	0	98-100	99 - 100	99 - 100	99 - 100
Schools	95-99	<1	<1	0	0	94-100	98 - 100	99 - 100	99 - 100
User Defined	94-96	3-5	<1 – 1.5	<1	<1	94-96	98-99	99	99 - 100
Utilities									
Potable Water	98-100	<1-2	<1	0	0	99 - 100	99 - 100	99 - 100	99 - 100
Wastewater	98-100	<1-2	<1	0	0	99 - 100	99 - 100	99 - 100	99 - 100
Electric Power	96-99	<1	<1	0	0	99 - 100	99 - 100	99 - 100	99 - 100
Communication	98-100	<1-2	<1	0	0	99 - 100	99 - 100	99 - 100	99 - 100

Source: HAZUS-MH 2.1

Table 5.4.3-15. Estimated Damage and Loss of Functionality for Critical Facilities and Utilities in Suffolk County for the 2,500-Year MRP Earthquake Event

Name	Percent Probability of Sustaining Damage					Percent Functionality			
	None	Slight	Moderate	Extensive	Complete	Day 1	Day 7	Day 30	Day 90
Critical Facilities									
EOC	67-96	<1 - 16	0-15	0-1	<1	67-95	83-99	98-99	99 - 100
Medical	67-95	4-17	1-15	0-1	<1	67-95	83-98	98-99	99 - 100
Police	67-95	3-17	1-15	0-1	<1	67-95	82-99	98-99	99 - 100
Fire	67-95	3-17	1-15	0-1	<1	67-95	82-99	98-99	99 - 100
Schools	67-95	<1 - 19	1-15	0-2	<1	66-95	82-98	97-99	99 - 100
User Defined	63-80	13-20	6-13	1-3	<1	63-80	83-93	96-99	99 - 100
Utilities									
Potable Water	65-96	3-17	1-16	0-2	<1	80-98	97-99	99-100	99 - 100
Wastewater	66-95	4-17	1-16	0-2	<1	73-96	97-99	98-99	99 - 100
Electric Power	35-93	5-43	2-19	0-2	<1	59-96	99	99	99 - 100
Communication	66-96	3-17	1-16	0-2	<1	91-99	99	99	99 - 100

Source: HAZUS-MH 2.1

Impact on Economy

Earthquakes also have impacts on the economy, including: loss of business function, damage to inventory, relocation costs, wage loss and rental loss due to the repair/replacement of buildings. A Level 2 HAZUS-MH analysis estimates the total economic loss associated with each earthquake scenario, which includes building- and lifeline-related losses (transportation and utility losses) based on the available inventory (facility [or GIS point] data only). Direct building losses are the estimated costs to repair or replace the damage caused to the building. This is reported in the "Impact on General Building Stock" subsection discussed earlier in this section. Lifeline-related losses include the direct repair cost to transportation and utility systems and are reported in terms of the probability of reaching or exceeding a specified level of damage when subjected to a given level of ground motion. Additionally, economic loss includes business interruption losses associated with the inability to operate a business due to the damage sustained during the earthquake as well as temporary living expenses for those displaced. These losses are discussed below.

It is significant to note that for the 500-year event, HAZUS-MH 2.1 estimates the County will incur approximately $57.5 million in income losses (wage, rental, relocation and capital-related losses) in addition to the 500 –year event structural, non-structural, content and inventory losses ($497 million).

For the 2,500-year event, HAZUS-MH 2.1 estimates the County will incur approximately $708 million in income losses, mainly to the residential and commercial occupancy classes associated with wage, rental, relocation and capital-related losses. In addition, the 2,500-year event structural, non-structural, content and inventory losses equate to greater than an estimated $8.3 billion.

Roadway segments and railroad tracks may experience damage due to ground failure and regional transportation and distribution of these materials will be interrupted as a result of an earthquake event. Losses to the community that result from damages to lifelines can be much greater than the cost of repair (HAZUS-MH 2.1 Earthquake User Manual, 2012).

Earthquake events can significantly impact road bridges. These are important because they often provide the only access to certain neighborhoods. Since softer soils can generally follow floodplain boundaries, bridges that cross watercourses should be considered vulnerable. A key factor in the degree of vulnerability will be the age of the facility or infrastructure, which will help indicate to which standards the facility was built. HAZUS-MH estimates the long-term economic impacts to the County for 15-years after the earthquake event. In terms of the transportation infrastructure, HAZUS-MH estimtes $7.8 billion in direct repair costs to bridges and $6.8 billion in repair costs to highway segements in the County as a result of a 2,500-year event. There are no losses computed by HAZUS for business interruption due to transportation or utility lifeline losses.

HAZUS-MH 2.1 also estimates the volume of debris that may be generated as a result of an earthquake event to enable the study region to prepare and rapidly and efficiently manage debris removal and disposal. Debris estimates are divided into two categories: (1) reinforced concrete and steel that require special equipment to break it up before it can be transported, and (2) brick, wood and other debris that can be loaded directly onto trucks with bulldozers (HAZUS-MH Earthquake User's Manual).

For the 100-year MRP event, HAZUS-MH 2.1 estimates 0 tons of debris will be generated. For the 500-year MRP event, HAZUS-MH 2.1 estimates more than 130,000 tons of debris will be generated. For the 2,500-year MRP event, HAZUS-MH 2.1 estimates greater than 1.4 million tons of debris will be generated. Of the total amount, brick/wood comprises 60% of the total with the remainder being reinforced concrete/steel.

Table 5.4.3-16. Estimated Debris Generated by the 500- and 2,500-year MRP Earthquake Events

Town	500-Year		2,500-Year	
	Brick/Wood (tons)	Concrete/Steel (tons)	Brick/Wood (tons)	Concrete/Steel (tons)
Babylon (T)	13,740	5,085	121,606	108,519
Brookhaven (T)	30,366	7,519	244,646	121,171
East Hampton (T)	1,507	309	11,167	3,649
Huntington (T)	14,335	4,300	123,348	78,878
Islip (T)	19,429	6,254	165,050	120,073
Riverhead (T)	3,031	1,032	23,418	16,939
Shelter Island (T)	130	23	1,152	313
Smithtown (T)	9,149	2,384	78,669	43,163
Southampton (T)	6,286	1,360	44,269	15,956
Southold (T)	2,310	619	16,381	8,410
Suffolk County	**100,281**	**28,884**	**829,707**	**517,070**

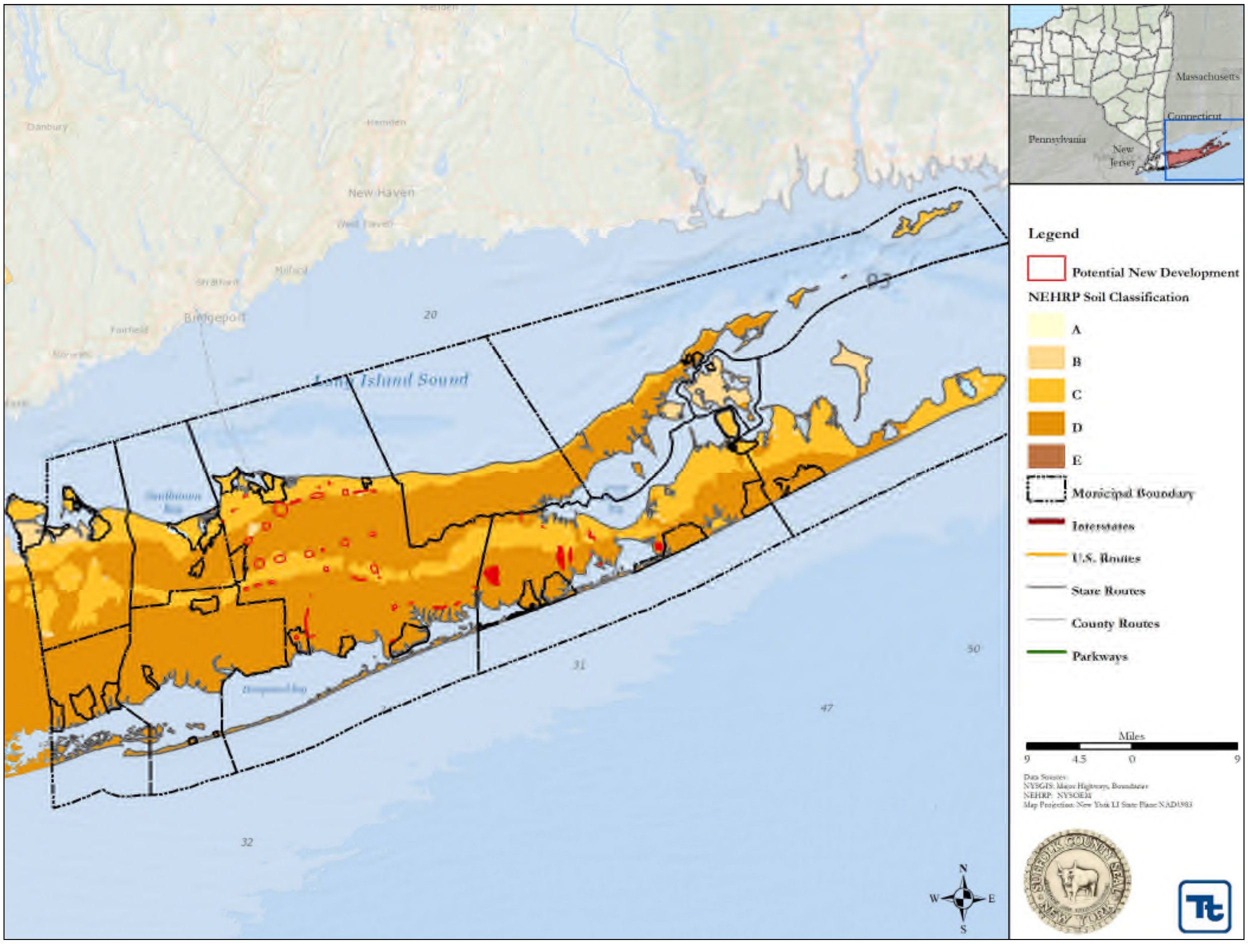
Source: HAZUS-MH 2.1

Future Growth and Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the County. It is anticipated that the human exposure and vulnerability to earthquake impacts in newly developed areas will be similar to those that currently exist within the County. Current building codes require seismic provisions that should render new construction less vulnerable to seismic impacts than older, existing construction that may have been built to lower construction standards.

New development located in areas with softer NEHRP soil classes may be more vulnerable to the earthquake hazard. Refer to Section 4, and Volume II Section 9 for potential new development and approximate NEHRP soil class areas in Suffolk County.

Figure 5.4.3-12. Potential New Development in Suffolk County and NEHRP Soil Types



Source: NYSOEM; Planning Committee

Change of Vulnerability

Suffolk County and all plan participants continue to be vulnerable to the earthquake hazard. However, there are differences between the potential loss estimates between this plan update to the results in the original 2008 HMP. Their differences are due to the updated building inventory and critical faciliies used and any changes to the HAZUS-MH model made by HAZUS developers. The results reported in the 2008 HMP were from models run in HAZUS-MH MR3; this plan update used the latest available version of HAZUS-MH (version 2.1).

Effect of Climate Change on Vulnerability

Providing projections of future climate change for a specific region is challenging. Some scientists feel that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the Earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. National Aeronautics and Space Administration (NASA) and USGS scientists found that retreating glaciers in southern Alaska might be opening the way for future earthquakes.

Secondary impacts of earthquakes could be magnified by future climate change. Soils saturated by repetitive storms could experience liquefaction during seismic activity because of the increased saturation. Dams storing increased volumes of water from changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts.

Additional Data and Next Steps

A Level 2 HAZUS-MH earthquake analysis was conducted for Suffolk County using the default model data, with the exception of the updated building and critical facility inventories which included user-defined data, and NEHRP soil data. Additional data needed to further refine the County's vulnerability assessment include: (1) updated demographic data to update the default data in HAZUS-MH; and (2) soil liquefaction data. Additionally, the County can identify un-reinforced masonry critical facilities and privately-owned buildings (i.e., residences) using local knowledge and/or pictometry/orthophotos. These buildings may not withstand earthquakes of certain magnitudes and plans to provide emergency response/recovery efforts for these properties can be set in place. Further mitigation actions include training of County and municipal personnel to provide post-hazard event rapid visual damage assessments, increase of County and local debris management and logistic capabilities, and revised regulations to prevent additional construction of non-reinforced masonry buildings.